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Observations on some American Rhizobia.

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Plates CXXIX and CXXX.

The purpose of this paper is: first, to give a short review of "Pilzsymbiosis;" second to point out and discuss somewhat the existing controversies; and third, to show that there are probably more than one species of *Rhizobium*.

It is only within recent years that the symbiotic relations of fungi with plants have been discovered and studied. Half a century ago some of the fungi which are now known to be symbiotic were studied and described without suspecting their real nature. Theo. Hartig in 1840 made drawings and gave a description of the "mykorhiza" of *Pinus sylvestris*, taking it to be a purely parasitic fungus. With this in view, at the "Botanischer Verein in München," Nov. 11, 1885, R. Hartig criticises Frank for claiming to have discovered the symbiotic relations of *Rosellinia quercina* with the oak To my knowledge nothing of any moment had been done on Pilzsymbiosis prior to 1885. B. Frank no doubt is the most earnest worker and has done more than any other man to clear up some of the mysteries concerning the subject. Probably he often becomes too enthusiastic over his discoveries, claiming for instances that many trees, especially of the Cupuliferæ, cannot develop without the symbiotic fungi. R. Hartig seems to be of the opposite turn of mind. In his "Anatomie und Physiologie der Pflanzen," 1891, he sums up Pilzsymbiosis as follows: "Fungi probably belonging to the Tuberaceæ or Gastromyceteæ are found parasitic on, or symbiotic with certain

trees, especially the Coniferæ and Cupuliferæ. In some cases they form a true mycorhiza (fungus root)." He does not seem to think that these fungi are of any use to the plant, but, on the contrary, more or less harmful by taking nourishment properly belonging to the plant. The hypertrophic condition of the infested root is probably caused by an irritating substance secreted by the fungus. But many forest trees of different varieties showed no traces of the root fungus.

In 1887 Hellriegel and Willforth concluded a long series of experiments which led to a new hypothesis in regard to the free-nitrogen-assimilating function of the Leguminosæ. Notes on these experiments dated back from the years 1862 and 1863. They were conducted under the direct supervision of Hellriegel. Among his assistants were H. Roemer, R. Günther, H. Moeller and G. Wimmer. Without going into details their conclusions may be summed up as follows:

1. Leguminous plants develop in sterilized soil.

2. Addition of sterilized nitrates increased their growth.

3. In harvest time there was no excess of stored nitrogenous material which could have come from any other source than the soil.

4. In non-sterilized soil the Leguminosæ developed better than in sterilized soil, especially if there was added a solution made from soil in which leguminous plants had grown (culture soil solution).

5. In harvest time there was found stored up in the plant an overplus of nitrogenous compounds which could not have been taken from the soil.

6. Leguminous plants in sterilized soil to which only a small amount of the above mentioned culture soil solution was added showed this overplus of nitrogenous compounds.

7. One and the same Leguminous variety did not give like results with different culture soil solutions.

8. Leguminosæ in non-sterilized or sterilized soil inoculated with the culture soil solution developed tubercles.

9. Leguminosæ in sterilized soil developed no tubercles.

10. In the same plant, if one side of the root was dipped in

normal culture soil solution and the other in sterilized culture soil solution the former developed tubercles, the latter not.

11. A period of dwarfed growth was noticed after inoculation with the culture fluid.

12. During this period tubercles kept on developing.

13. In soil free from nitrates active growth began only after the formation of tubercles.

Hellriegel's final summing up is as follows:

1. The Leguminosæ have another source besides the soil from which to draw free nitrogen.

2. This second source is the free nitrogen of the air.

3. The plant itself has not the power to assimilate this free nitrogen.

4. Active micro-organisms perform this function for the plant.

5. The tubercles stand in intimate relations with the free nitrogen assimilating power of the Leguminosæ.

In 1890 Frank wrote an article entitled "Pilzsymbiose der Leguminosen" in which he not only verified Hellriegel's conclusions, but also studied and described the micro-organisms connected with this nitrogen-assimilating function. His conclusions may be briefly summed up as follows:

1. Some Leguminosæ live in symbiotic relations with a very simple fungus which infects the plant as soon as it begins to develop.

2. This fungus belongs with the smallest organisms. It is one of the Schizomycetes, the *Rhizobium leguminosarum.*

3. It very likely develops and multiplies in the soil. It is present in all natural soils, at least to some extent.

4. Roots of the Leguminosæ have the property of excreting a peculiar substance which attracts the spores of the fungus. Some of these spores develop on the outside of the root, others are conducted into the interior of the root tissue by peculiar protoplasmic strands built up by the normal cells of the plant (*Infektionsfäden*).

5. The fungi combine with the protoplasm of the cells, forming a mixture called "mycoplasm." The fungus may be found in nearly all parts of the plant, even in the seed. A new plant may be infected from the spores in the embryo.

6. At the point of infection a tubercle develops. This consists of parenchymatous tissue rich in protoplasm in which the spores develop and multiply very rapidly.

7. The mycoplasm becomes differentiated into nitrogenous (albuminous) "Formelemente"—the "Bakteroiden." These resemble bacteria.

8. At the close of vegetation these stored bacteria-like collections of albuminous substances are again absorbed and utilized by the plant.

9. Some tubercle-producing fungi of the Leguminosæ are purely parasitic; that of *Phaseolus vulgaris* probably belongs to this group.

10. In most Leguminosæ the *Rhizobia* have the power of appropriating for the use of the plant free nitrogen of the air.

11. There is probably only one species of the *Rhizobium* which is present in all normal soils.

12. Leguminosæ in rich soil develop few, if any tubercles. Plants in poor soil stand in closer symbiotic relations with the *Rhizobia.*

Frank's conclusions in regard to Pilzsymbiosis as they appear in Heft 7, 1891 of the "Berichte der Deutschen Botanischen Gesellschaft" may be briefly summarised as follows:

1. Endotrophic mykorhiza is found in roots of Orchids, Ericaceæ and other plants.

2. In the Orchids the mykorhiza consists of a collection of yellowish interwoven septate hyphæ, generally found in epidermal cells of the root or rhizome.

3. The fungus during its whole life-course lives within the root cells of the host.

4. Nuclei of infected cells become much enlarged, showing an increased activity of cell protoplasm.

5. The living protoplasm of the root cells absorbs the protoplasm of the fungus. This is observed in roots that approach the period of decay.

6. The fungus is at first nourished by the cell protoplasm, which changes it so as to render it unable to grow outside of the root cell.

In regard to the mykorhiza of Ericaceæ, Frank comes to

similar conclusions. His pupil Schlicht has found fungi in roots of the following families. Ranunculaceæ, Leguminosæ, Rosaceæ, Œnotheraceæ, Umbeliferæ, Geraniaceæ, Oxalidæ, Hypericaceæ, Violaceæ, Primulaceæ, Labiatæ, Boragineæ, Dipsaceæ, Valerianaceæ, Plantagineæ, Rubiaceæ, Smilaceæ, Compositæ, Gramineæ. The true nature of the *Rhizobia* in these numerous families is not known in most cases.

In regard to symbiosis of the Leguminosæ in the same article Frank comes to the following conclusions:

1. At least some of the Leguminosæ live in symbiotic relations with a fungus with which the plant becomes infected as soon as it begins to develop in normal soil.

2. This fungus has specific properties belonging to the Schizomycetes; it is the *Rhizobium leguminosarum.*

3. The fungus probably develops and multiplies to some extent in the soil.

4. The roots of the Leguminosæ have the power of attracting the fungus. This is probably due to some peculiar secretion.

5. The manner of infection is the same as described in 1890.

6. The "Bakteroiden" of 1890 are now considered true fungi. They are, however, much modified through the assimilation of cell protoplasm.

7. These modified fungi will not multiply outside of the vegetable cell.

8. A few normal fungi are always left over, which pass into the soil ready to infect other developing plants.

9. There is only one species of *Rhizobium.*

In comparing Frank's résumé of 1890 with that of 1891 the following differences are noted: the Bakteroiden are not albuminous differentiations of the mycoplasm, but they are considered to be true, much-altered *Rhizobia* and these modified *Rhizobia* cannot grow and multiply outside of the vegetable cell. He admits that in his former decision in favor of Bakteroiden he had been influenced by Brunchorst. Woronin in 1866 was the first who maintained that the Bakteroiden of Brunchorst were true bacteria. Indeed, Frank thought for a time that all the controversy about Bakteroiden being living organisms was due to Woronin. In the last year or two the strongest arguments are with Frank's latest

decision (1891). M. Ward took the Bakteroiden to be the spores of a true hyphal fungus. Ericksson also took them for a spore or bacterioid buddings from true hyphæ.

The "Infectionsfäden" seem to be another cause of much controversy. Frank formerly likened them to the *Schinzia* (*Plasmodiophora*) *Alni* of Woronin and called them *Schinzia leguminosarum*. As will be seen from his conclusions of 1890 and 1891 he definitely states that they are not a fungus, but a production of the normal plant cells used for the purpose of infection. M. Ward took the Infektionsfäden for the real fungus of which the Bakteroiden were the spores. Prazmowski at first took them for plasmodia filled with small rod-like bodies. As soon as the plasmodium enters the root cells it surrounds the entire cell contents so that plasmodium and cell contents can not be distinguished. Later he changes his opinion and takes the Infektionsfäden for hyphæ-like tubes filled with bacteria. That is, the hyphæ-like tubes, if not identical with Frank's Infektionsfäden, at least have a similar function. Schroeter seems to be satisfied that the Infektionsfäden are true plasmodia made up of swarm spores of his *Phytomyxa leguminosarum*.

At present I shall not enter into any further discussions of existing controversies, but shall proceed with my own observations and resultant conclusions. In my observations I studied the *Rhizobia* as I found them in the various Leguminosæ. Frank and Beyerinck, so far as I can learn, made their principal observations on culture *Rhizobia*. These cultures are apt to lead to erroneous results for three reasons: First, because but little is at present known of their behavior outside of their host; second, because the same tubercle may contain a variety of *Rhizobia* and other bacteria, especially tubercles that have begun to break down—these would be liable to influence the culture formations; third, because of the well known fact that culture fluids greatly modify the appearance of bacteria. Frank seems to give no plausible reason why there should be but one species of *Rhizobium*. Frank and Beyerinck both admit that this one species occurs in a variety of forms, Y-shaped, oblong, curved, etc. In the examination of normal culture soil solution I found not only a variety of *Rhizobia*, but also a host of other bacteria, bacilli and micro-

cocci. That all *Rhizobia* may have a similar function, that of assimilating free nitrogen, does not indicate that there must be but one species. Even since Frank maintains that the Bakteroiden are true, though modified, *Rhizobia* he seems to believe that there is but one species. In 1890 he declared that the micrococci-like *Rhizobia* were contained within the Bakteroiden which, according to his recent conclusions in regard to Bakteroiden, would be absurd or at least improbable.

Frank also seems to take it for granted that the plant or rather root has some attractive influence on the *Rhizobia*. He gives no cause for this assumption, nor do experiments bear him out. Capillarity, wind and water are the principal agents for the distribution of micro-organisms in soil. Air currents carry them from place to place on the surface of the soil. Rain, for instance, carries them deeper into the soil and brings them in contact with roots and rootlets; these with their root hairs and probably a sticky secretion, arrest them and infection takes place at suitable points. Capillarity will either carry them down or up, that depending upon the condition of the soil as to moisture. Hellriegel and Beyerinck have shown that when a leguminous plant was planted in sterilized soil and one side sprinkled with normal culture soil solution and the other with sterilized culture solution, the former developed tubercles while the latter did not. Now if the roots had any attractive influence they would certainly have drawn some of the *Rhizobia* from the infected to the non-infected side.

The purpose of my observations was primarily to settle the following questions:

(1). Do all the tubercles of the Leguminosæ contain one and the same micro-organism?

(2). Do all the micro-organisms undergo a modification of form in all infected Leguminosæ?

(3). Is the micro-organism a *Rhizobium* or a *Phytomyxa?*

In May, 1891, I examined the tubercles of *Trifolium pratense* and *T. repens* and noted the appearance of the contained *Rhizobia*. They were as shown in fig. 1, plate CXXX. Later, in June and July I examined tubercles of *Amphicarpaea comosa, Cassia Chamæcrista, Trifolium repens, T. pratense, Melilotus alba, Pha-*

seolus vulgaris, *P. pauciflorus*, *Lathyrus odoratus*, *Pisum sativum* and *Robinia Pseudacacia*. According to the statements of Frank I expected to find in each species examined the same kind of *Rhizobium*, though perhaps somewhat modified. This, however, was not the case. In *Melilotus alba*, *Trifolium repens*, *T. pratense* and *Lathyrus odoratus*, I found the cells of the infected area of tubercles entirely filled with the peculiar Y-shaped organisms, (the "Bakteroiden" of Brunchorst, bacteria of Woronin, spores or gemmules of Ward, etc.) (fig, 1, plate CXXX.) The same tubercles examined in June and July showed the same organisms, though much changed in appearance. They were larger, and the majority took on the Indian-club form. They had become fattened on the cell protoplasm (fig. 2, plate CXXX). The same tubercles examined in September and October showed the organisms still more modified. Some of them had become almost spherical, others oval-dumb-bell shaped, etc. In some the plant had begun to reabsorb the protoplasmic contents, as shown in *a*, fig. 3, plate CXXX. The same tubercles, examined late in October and beginning of November, showed that most of them had begun to break down, and the contained *Rhizobia* had their entire protoplasmic contents reabsorbed by the plant, leaving nothing but the empty, partially absorbed or decayed walls (fig. 3, plate CXXX). In these tubercles were also found a variety of bacteria spores and *Rhizobia* (?) that were not present while the tubercle was intact. Very likely these were foreign to the plant, and had been brought to and deposited in the partially destroyed tubercle by water currents and capillarity. Probably these foreign spores, bacteria and *Rhizobia* (?) were the organisms which Frank took to be the unmodified remnants and spores of the true *Rhizobium leguminosarum* left behind after the protoplasmic contents had been reabsorbed by the plant. Several culture attempts on gelatine in July proved to be failures. This confirms Frank's statements that the modified *Rhizobia* will not reproduce and develop outside of the host. Neither by the aid of various stains or the use of K H O solution was I enabled to detect the presence of spores. I am inclined to the belief that they multiply by direct division only.

In the examination of the tubercles of *Phaseolus pauciflorus* I

found the cells of the infected area entirely filled with curved *Rhizobia*, resembling the comma bacillus of Koch. Staining with eosin or fuchsine brought into view a spore at either end. Their form was so constant and even that I could not bring myself to imagine that they were identical with the *Rhizobia* of *Melilotus alba*, for example. Furthermore they retained their constant form throughout the entire year. The *Rhizobia* of *Phaseolus vulgaris* were still different—they were straight, in form constant, in size quite variable. There were spherical spores, one at either end, rarely only one. The spores of the curved *Rhizobia* were hemispherical. The *Rhizobia* of *Pisum sativum* corresponded exactly with those of *Phaseolus vulgaris*, only that they were smaller. *Dalea alopecuroides*, *Robinia pseudacacia* and *Cassia Chamæcrista* contained a *Rhizobium* differing from any of the ones described above. It presented a knotted, irregular outline; generally three spores, sometimes one, rarely two. The *Rhizobia* of *Amphicarpæa comosa* differed from the one just described in that the spores were placed some distance from the ends. They were also somewhat smaller, as will be seen from the table of measurements. From these observations I felt satisfied that there was more than one species of *Rhizobium*, and that they did not all take part in that change of form so well marked in the first described species. The question might be raised whether the protoplasmic contents of the *Rhizobia* are in all cases reabsorbed by the plant or whether they, at least in some cases, simply die and disintegrate for want of food supply. It is known that in all cases the tubercles are destroyed towards the close of vegetation, thus liberating the remaining *Rhizobia*.

As already stated, Schroeter took the Infektionsfäden to be true plasmodia of his *Phytomyxa leguminosarum*,=Frank's *Rhizobium*. Now the Infektionsfäden are very prominent in *Trifolium pratense* but its *Rhizobia* contain no spore whatever so far as I have been able to make out, so the Infektionsfäden cannot be the plasmodium of the *Rhizobium* of white clover. Furthermore the Infektionsfäden are absent in many species infected with the *Rhizobia* or *Phytomyxa*. So instead of placing the *Rhizobia* with *Myxomycetes*, according to Schroeter, it is better to place them with the Schizomycetes, according to Frank; because their

composition, development, methods of reproduction and general behavior correspond to those of the Schizomycetes.

Frank claims to have seen the spores of *Rhizobium* within the Infektionsfäden. I have been unable to find anything in them except a granular, spongy (*schaunmiges*) appearance when treated with K H O solution. These Infektionsfäden are not present in all tubercles, for instance, those of *Phascolus vulgaris*, *Pisum sativum*, *Robinia Pseudacacia*. Nor are the "infecting strands" always absent where Frank thinks they are not needed. I have found them in young *Phascolus vulgaris;* have traced them in tissues opposite the tubercle, or some distance from the tubercle, having no connection with it. Nor do these "strands" generally originate in a root hair, but more often from the epidermal layer of root cells, where they begin as a small spherical protoplasmic lump, as shown at *a*, fig. 1, plate CXXIX. These infecting strands seem to have no outer wall; they are nonseptate, branching, interlacing, passing directly through the protoplasm and wall. Their protoplasm is of a different consistency from that of either the cell or *Rhizobia*. It is more resistant toward chemicals and staining fluids. It remains after the protoplasm of cell and *Rhizobia* have been used up. It is more than likely that these Infektionsfäden have nothing to do with the *Rhizobia;* because, they are not present in all cases, and when present, are not always in or near tubercles. I could detect no spores in them. They are present in tubercles of *Trifolium repens*, whose *Rhizobia* have no spores. I found them in young *Phaseolus vulgaris*, where Frank says they are not needed. Since infection in some cases takes place without the "strands," may it not do so in all cases?

The form of the tubercle seem to have nothing to do with the kind of infecting *Rhizobia*. In *Dalea alopecuroides* and *Lathyrus odoratus*, for instance, are found similar tubercles as to form and size, but they contain distinct *Rhizobia*. I did not notice much regularity as to the position and distribution of tubercles. They are usually more numerous near the surface of the ground. They may be found on the main root or on its branches. In *Trifolium repens* and *T. pratense* they seem to form more often where rootlets branch. The root hairs on tubercles are usually few and dwarfed, as shown in fig. 1, plate CXXIX.

The histology of the tubercle may be briefly considered as follows:—The tubercle consists of a collection of abnormally large parenchyma cells whose protoplasm and nuclei are much modified: The nuclei are much enlarged, chromatine prominent, *Rhizobia* imbedded in the cell protoplasm, all division very active, thus producing new and infected cells. Beginning on the outside in examining a section of tubercle, the following layers may be described. Epidermal layer, no root cap; non-infected area one, two or more layers thick; immediately below that is the starch-bearing zone entirely surrounding the infected area, and continuous with the starch-bearing layer of the vascular bundle. The remainder of the tubercle is the infected area filled with *Rhizobia* and some starch granules. No starch is present in cells entirely filled with the *Rhizobia*. The plant no doubt requires the protoplasm of the *Rhizobia* from which to build starch. Between the infected and non-infected area, and including the starch-bearing zone, the cells are partially filled with *Rhizobia*, (see fig. 1, plate CXXIX).

Tubercles had been noticed by some of the older botanists. Malphighi took them for animal galls; Treviranus (Bot. Zeit., 1853) for adventitious buds; DeCandolle for pathological growths; Clos for lenticels. Their real nature was not suspected.

SYSTEM OF "RHIZOBIA."

SCHIZOMYCETES.

MYCODOMATIÆ.

Rhizobia developing and living in root tubercles of variable size and form. Tubercles always on main root or its branches, and decaying at the close of vegetation.

Rhizobium mutabile, n. sp.

Syn.: *Bakteria*, Woronin.
Bakteroiden, Brunchorst.
Spores or gemmules, Ward.
Bacillus radicicola, Beyerinck in part.

This species was first discovered and probably the most common. It may be that this species, above all others, has the power to assimilate free nitrogen. Experiments will be necessary to determine that point. As is seen from the synonyms, some

authorities took this species for an organism and others did not. Woronin was the first to place it among living organism, the bacteria. Beyerinck believed that they were modified bacilli. Ward maintained that they were the budded-off gemmules or spores of a true hyphal fungus, as already explained. Brunchorst, and also Frank, said they were bacterioid collections of albuminios substances formed from the cell protoplasm. Recently Frank claims that they are true *Rhizobia*, because plasmolysis causes them to contract like living protoplasm.

I have found this species symbiotic with *Trifolium pratense* and *T. repens*, *Melilotus alba* and *Lathyrus odoratus*. It is at once recognized by its size and the varying form it takes on during the vegetation period. It was impossible for me to detect the presence of spores during any time of its existence. It very likely multiplies by division only. The tubercles produced are oblong or irregular, varying in size from that of a pin head to that of a small pea; sometimes they are collected in large grape-like bunches, as in *Melilotus alba*. The modified organisms do not develop upon gelatine or agar-agar cultures. They are surrounded by a gelatinous zone.

Rhizobium curvum, n. s.

Syn.: *Rhizobium leguminosarum*, Frank.
Phytomyxa leguminosarum, Schroeter.
Cladochytrium leguminosarum, Vuillemin.
Bacillus radicicola, Beyerinck.
Pasteuriaciæ, Laurent.
} in part.

Symbiotic with *Phaseolus pauciflorus*. Cells curved, resembling the comma bacillus of Koch. One hemispherical spore at each end, rarely more. Size quite uniform, and form constant during entire vegetative period. Gelatinous zone present. Tubercles spherical, varying in size from that of a pea to that of a small hazel nut.

Rhizobium Frankii, n. s., var. *majus*, n. v.

Syn.: Same as preceding.

Symbiotic with *Phaseolus vulgaris*. Cells straight, generally two or three times as long as broad. Size variable. Two spherical spores, one at either end, sometimes one, rarely none. Spores

larger than in the preceding. External gelatinous coat. Tubercles small, spherical, comparatively few in number.

Rhizobium Frankii, var. *minus*, n. s.

Syn.: Same as preceding.

Symbiotic with *Pisum sativum*. It is smaller; otherwise like the preceding.

Rhizobium nodosum, n. s.

Syn.: Same as preceding.

Symbiotic with *Dalea alopecuroides*, *Robinia Pseudacacia* and *Cassia Chamæcrista*. Cells of an irregular, knotted appearance. Protoplasmic contents often collected in lumps. Generally one or three, rarely two, spores situated at the ends, with one somewhere near the middle. Sometimes an encapsuled chain of spores. Gelatinous zone present. Tubercles round, oblong or irregular, varying in size from that of a morphine pill to a large pea.

Rhizobium dubium, n. s.

Syn.: Same as preceding.

Symbiotic with *Amphicarpæa comosa*. General description corresponds with the preceding, only that it is somewhat smaller and the spores are not situated in contact with the end walls as in all the preceding; but small distances from them. Tubercles spherical, about half as large as a pea. Considerable starch in tubercles.

For better understanding of the above described species consult table of measurements and plate CXXX.

TABLE OF MEASUREMENTS.

	LENGTH.	WIDTH.
	μ	μ
Rhizobium mutabile in May, ...	3-4	.8
" " " July, ...	6.4	1
" " " September, . . .	5-8	2-3.5
" *curvum*, ...	1.9	.6
" *Frankii*, var. *majus*, . . .	.8-3	.6
" " " *minus*, ...	.6-1.4	.5
" *nodosum*	1.6-3.5	.8
" *dubium*	1.6-2.4	.6

Settled Facts.

1. That certain fungi are symbiotic in and on roots of certain plants.

2. Some of these fungi are purely parasitic, while others have the power of assimilating for the use of the plant free nitrogen of the air.

3. Plants can exist without these fungi, but as a rule thrive better with them.

4. At the close of vegetation, and also on other special occasions, the plant reabsorbs the protoplasm of the fungi.

5. The Infektionsfäden are not hyphæ of which the Bakteroiden are the spores or gemmules.

Probable Facts.

1. That there are at least several species of *Rhizobium.*

2. That the Infektionsfäden have nothing to do with the *Rhizobia* under consideration.

3. That the *Rhizobia* belong to the Schizomycetes.

4. That *Rhizobium mutabile* has no spores.

5 That the Infektionsfäden are true hyphal fungi allied to *Schinzia Alni.*

Improbabilities.

1. That the Infektionsfäden are plasmodia.

2. That the *Bakteroiden* are not living organisms.

3. That the plant exerts any attractive influence upon the *Rhizobia.*

4. That some plants cannot exist without the symbiotic fungus.

The researches of which this paper is a partial record, were undertaken in 1890 and 1891, in the Laboratories of Botany, at the University of Minnesota, in Minneapolis.

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EXPLANATION OF PLATES.

PLATE CXXIX.

Fig. 1. Longitudinal section of *Trifolium repens* rootlet with a developing tubercle; stained with water-eosin. *a*, *Infektionsfäden* of Frank, *hyphæ* of Ward and Vuillemin, *plasmodia* of Prazmowski (?) and Schroeter. One of them is opposite the tubercle, having no connection with it. One originates in a root-hair, *h*,

They are probably true hyphal fungi closely related to the *Schinzia Alni* of Woronin. *c*. Infected area. Only cell walls and the contained *Rhizobia* are shown. *d*, Dwarfed root-hairs on tubercle. *e*, Normal root-hairs, one infected with *Rhizobia*. *f*. Vascular bundle. *g*, Starch-bearing area surrounding entire infected area.

Fig. 2. Portion of infected area somewhat more magnified showing distribution of *Infektionsfäden*, Nuclei and cell protoplasm are not shown. *a*. Cell filled with *Rhizobia*. *d*, Infecting strands. *b*, Infektionsfäden are somewhat expanded near cell wall. *e*, *Haustoria* of Kny. Expanded knobbed extension from the strands.

Fig. 3. Rootlet of *Melilotus alba*. *a*, Developing tubercles. *b*, Single tubercles. *c*, Grape-like bunches of tubercles, slightly magnified.

Fig. 4. Rootlet of *Amphicarpæa comosa* with spherical tubercles.

Fig. 5. Rootlet of *Dalea alopecuroides*. Tubercles resembling those of *Melilotus alba* and *Trifolium pratense* and *T. repens* though somewhat larger.

Fig. 6. Portion of infected arc of *Trifolium repens* showing nuclei treated with KHO solution, and cell protoplasm (mycoplasm). *a*, Nucleus enlarged. *b*, Cell protoplasm (mycoplasm). partially used by the plant containing modified *Rhizobium mutabile*. *c*, *Infektionsfäden*. They seem to be entirely independent of cell nuclei and mycoplasm. *d*, *Haustoria* of Kny. They do not appear granular while the strands do.

Plate CXXX.

Fig. 1. *Rhizobium mutabile* as it appears in May, or the time of infection.

Fig. 2. The same in June and July.

Fig. 3. The same in September and October. *a*, A *Rhizobium* from which the plant has begun to reabsorb the contents.

Fig. 4. The same in October and November. a, Partially emptied *Rhizobia*. *b*, Entirely empty, nothing remaining but the partially destroyed walls. *c*, Normal forms which either had not undergone any change in the cell or had just gained access to the tubercle through its partially decayed distal end.

Fig. 5. *Rhizobium curvum*.

Fig 6. *Rhizobium Frankii*, var. *majus*.

Fig. 7. *Rhizobium Frankii*, var. *minus*.

Fig. 8. *Rhizobium nodosum*.

Fig. 9. *Rhizobium dubium*.

New or Noteworthy North American Phanerogams.—VI.

By N. L. Britton.

Ranunculus arvensis, L., which has been noticed on ballast about the eastern seaports for many years appears to be spreading. It was found by Mr. Wm. H. Rudkin at Tom's River, N. J., in 1884, and now Mr. Geo. V. Nash sends it from the vicinity of Clifton, Passaic Co., N. J.

Cardamine Pennsylvanica, Muhl. in Willd. Sp. Pl. iii. 486 (1800).

It has been a frequent topic of remark among American botanists that our *Cardamine hirsuta* is a glabrous plant. I have been interested for several years in accumulating a large number of specimens of the forms which have been referred to *C. hirsuta* and am convinced that the typical plant is rare in America, as is indicated in the sixth edition of Gray's Manual. Our common marsh and ditch plant differs from *C. hirsuta* in being glabrous or rarely with a few hairs on the petioles or leaf-margins, while all the European specimens of this species that I have seen are more or less pubescent on the stems, the upper surface of the leaf-segments or the petioles. *C. Pennsylvanica* is much larger and more leafy, being often two feet high; the leaves of *hirsuta* being mainly radical; the leaf-segments of *Pennsylvanica* are larger, more generally oblong or ovate, narrowed rather than rounded at the base, as is the case with those of *hirsuta*, and have a decided tendency to be decurrent on the rachis, while those of the European plant are nearly uniformly distinct and stalked; the leaf-segments of *Pennsylvanica* are also thinner and more lobed than those of *hirsuta*; the fruiting pedicels of *Pennsylvanica* are always somewhat spreading and sometimes conspicuously so, while those of *hirsuta* are nearly or quite erect and the pods appressed.

I have but a single specimen of true *C. hirsuta* from North America, collected by John K. Small, May 2, 1891, along the Susquehanna River, north of Wrightsville, York County, Penn. The question of its distribution will be an interesting one. Is it Northern or Alleghenian? Or perhaps introduced from Europe?

Cardamine parviflora, L. Sp. Pl. Ed. 2, 914 (1763).

In the "Transactions of the New York Academy of Sciences" ix. 8 (1889), I have maintained that the plant described by Dr. Gray (Man. Ed. 5, 67), as *Cardamine hirsuta*, var. *sylvatica*, is specifically distinct from *C. hirsuta*, and referred it to *C. flexuosa*, With., a European plant. I am satisfied now, as I was then, that it is distinct from *C. hirsuta*, but after a study of a long series of European specimens at Kew and the British Museum, I am equally satisfied that it is not *C. flexuosa*, but is *C. parviflora*, of which I have seen the original specimen in the Linnæan Herbarium. The equivalency of our plant with the European is noted by Watson and Coulter (Gray, Man. Ed. 6, 65). This species is evidently of northern range, occurring from Virginia and Pennsylvania to Quebec (according to Macoun) and Western Ontario.

As I now understand these plants there is still a third eastern species, the *Cardamine Virginica* of Michaux. (Fl. Bor. Am. ii. 29, 1803), and *C. hirsuta* var. *Virginica*, T. and G. Fl. N. A. i. 85, but not *C. Virginica*, L. This grows in sandy, open, moist soil along the Atlantic coast. It is very much branched at the base, forming numerous, ascending or erect leafy stems six inches to a foot high, the leaves nearly erect and divided into numerous linear or linear-oblong, obtuse or obtusish segments, those of the lower leaves broader than those of the upper, as in all this group. The fruiting pedicels are ascending and the pods strictly erect. The plant is apparently glabrous throughout. I have it from Middletown, Conn., "on sandy fields subject to be overflowed by the rivers" (J. Barratt), Huckleberry Island, Long Island Sound, (Mrs. Britton), and collected it myself on April 16th of this year at Portsmouth, Va., where it was in full fruit and flower, and impressed me by its very different appearance from any form with which I was familiar. As Michaux's name for the plant is preoccupied by the Linnæan, I propose for it CARDAMINE ARENICOLA.

Arabis Virginica (L.)

Cardamine Virginica, L. Sp. Pl. 656 (1753) not of Herbarium.

Cardamine Ludoviciana, Hook. Journ. Bot. i. 191 (1834).
Arabis Ludoviciana, Meyer Index Sem. Petr. ix. 60 (1843).
Arabis Virginica, Branner and Coville, Rep. Geol. Surv. Ark. for 1888, 165 (1891).

Messrs Branner and Coville, at the place above cited, express themselves as uncertain of the applicability of the Linnæan name to this species. They have taken it up correctly, however, although it has had a curious history. The specimen preserved under the name *Cardamine Virginica* in the Linnæan Herbarium is *Sisymbrium asperum*, L. of Southern Europe, which bears a wonderful resemblance to the plant of the Southern United States, readily distinguishable, however, by its glandular-roughened siliques, those of the our plant being perfectly glabrous. The foliage of the two species is practically identical. It is perfectly evident, however, from his description that Linnæus had only the American plant in mind, and this is proved by the types preserved at the British Museum of Natural History. I found no specimen of his *Sisymbrium asperum* except the one labelled *Cardamine Virginica*, in the Linnæan Herbarium, and it is clear that this one has been accidently fastened down to the wrong sheet.

AGRIMONIA MOLLIS (T. and G.).

Agrimonia Eupatoria, var. *mollis*, T. and G. Fl. N. A. i. 431 (1840).
Agrimonia pubescens, Wallr. Beitr. Bot. i. 45, t. 1. f. 7. (1842) ex descr.

This is another plant of this genus which I am sure deserves specific rank. I pointed out the characters of Wallroth's *A. microcarpa* in the BULLETIN, xviii. 367. The present plant, recognized as a variety by Torrey and Gray, has a slender canescent or pubescent stem, five to nine principal leaflets which are oblong or obovate, obtuse and equally dentate, small flowers and turbinate fruit, borne on erect, short pedicels and a glabrous, ribbed calyx 2 mm. high in fruit.

We have it from Red River (Dr. Pitcher, the type specimen of the variety), Riverdale, N. Y. (Bicknell), Little Neck, Long Island (Schrenk), Heiligs Mill, N. C. (Small and Heller, No. 321). The North Carolina specimen has tuberous thickened roots, as

especially remarked by the collectors, and these are also shown by Mr. Bicknell's plants from Riverdale.

FRAGARIA AMERICANA (Porter).

F. vesca, var. *β*, Torr. and Gray, Fl. N. A. i. 148 (1838).

F. vesca, var. *Americana*, Porter, Bull. Torr. Club, xvii. 15 (1890).

The characters of this plant have been well indicated by Prof. Porter. It differs from the European *F. vesca* in its thin, deeply and sharply dentate leaflets, which become glabrate in age, and superficial achenes which are scarcely or not at all imbedded in the ovoid fruit. I have seen no form of the European plant which very closely resembles it. It is an Appalachian and northern species, extending west to Michigan and south to Virginia, probably further both to the south and west. The introduced *F. vesca*, which occurs rather sparingly in the Eastern States, may usually be distinguished from *F. Virginiana* by a character not alluded to in recent text-books, but mentioned by Dr. Sturtevant in Mem. Torr. Club i. 183, 184; this is that in *F. vesca* the fruit is borne above the leaves, while in *F. Virginiana* the leaves rise above the fruit.

Fragaria Virginiana, Mill. Gard. Dict. Ed. 8, No. 2 (1768).

Miller is the author of the species rather than Duchesne, to whom it is usually ascribed, the date of Duchesne's publication in the second volume of Lamarck's Encyclopedia being 1786; Miller's type is preserved in the Herbarium of the British Museum of Natural History.

Fragaria Canadensis, Michx. Fl. Bor. Am. i. 299 (1803).

This plant, referred by recent authors to *F. Virginiana*, appears to me to be a distinct species. It is a slender plant, the hairs on the flowering scape appressed as in *F. Virginiana*, but the leaflets are much narrower, oblong or the middle one obovate and cuneate at the base, all obtuse, rather sparingly and not deeply toothed, averaging not more than 3 cm. long and 1.5 cm. wide, quite glabrous on the upper surface even when young, pale and more or less appressed, pubescent beneath; the flowers are few, about 1.5 cm., broad and slender pedicelled. I have not seen the fruit.

Michaux's plant, preserved in the Paris Herbarium, came from Lake Mistissini. We have specimens collected by Dr. Richardson in Arctic America, and by Kennicott on Elk River. The species is thus indicated as high northern in distribution.

Valeriana pauciflora, Michx. Fl. Bor. Am. i. 1803.

The pappus of this species is not described so far as I am able to ascertain. One of the essential characters of *Valeriana*, as the genus is recognized by recent authors, is the development of the calyx-teeth into plumose bristles. In *V. pauciflora*, however, I find no indication that this is the case, even in fruit which seems to be perfectly mature, which I have from Professor Porter, collected by him at Millersburg, Penn., in 1865. In this the calyx-teeth remain short and inrolled, are slightly ciliate, and about 0.5 mm. long. In the related *V. Arizonica*, A. Gray, the fruit of which was not known to the describer at all events at the time of description, but which I have from a specimen collected by Dr. Rusby on Bill Williams Mountain, Arizona, in 1883, the similar short inrolled calyx-teeth occur. Now both these species differ from all other Valerians that I have at hand to examine by their large, slender, elongated corollas, resembling in this character the European genus *Centranthus*. They do not agree with *Centranthus*, however, in other important particulars, this genus having an elongated pappus and only one stamen.

I am printing this note to call attention to the fruit of *V. pauciflora*, in the hope that some one may be able to examine it when perfectly mature, and to determine whether it ever develops the copious pappus of other species.

Stevia ovata, Raf. New Fl. N. A. iv. 73 (1836).

A specimen of this plant, which Rafinesque says was collected by Walton in "Texas and Arkanzas," is preserved in the Columbia College Herbarium, with Rafinesque's own label. It is quite the same as other specimens labelled *Stevia ovata* received from Meisner and grown in the Basel garden, and from the Liverpool Botanic Garden sent to Dr. Torrey by Mr. Stead, collected in 1820. Whether or not these specimens are all the same as *S. ovata*, Lag. Nov. Gen. et Sp. 27, which Mr. Hemsley records only from South Mexico, I have no means of ascertaining other

than the description. The locality cited by Rafinesque may be wrong, but it is worth while to record that his specimen is preserved.

ASTER CORDIFOLUS, L. var. INCISUS, n. var.

Leaves all lanceolate, glabrous, sharply serrate, or the lower incised, none of them cordate at base. Pocono Mountain, Penn. (Moser, 1832); near Riverdale, N. Y. (Bicknell, 1891).

Dr. Gray alludes to Moser's Pocono specimen in the Synoptical Flora as an extreme form of *A. cordifolius*. This plant appears to me worthy of varietal rank. It is nearest var. *lanceolatus*, Porter, BULLETIN, xvi. 68.

POLEMONIUM VAN-BRUNTIÆ, n. sp. (Plate CXXXI).

Rootstock stout, horizontal. Stems erect, glabrous below, somewhat glandular-pubescent above, 6-8 dm. high, leafy to the top; leaflets of the lower leaves 15-19, short-petioluled, or sessile, ovate or lanceolate, 1½-3½ cm. long, 5-15 mm. wide, those of the upper ones fewer; cymose clusters panicled or solitary, rather loosely 3-8 flowered; flowers bluish-purple, 15-20 mm. broad; petals rounded; calyx 5-lobed to about the middle, much enlarged in fruit, the lobes acute or acutish; stamens exserted; ovules 3-4 in each cell of the ovary.

In cold, wet places, New York—Herkimer Co. (Clinton); Delaware Co. (Gilbert); Schoharie Co. (Howe); Ulster Co., Balsam Lake (Mrs. Van Brunt); Alder Lake (Rusby); Chenango Co., Preston and McDonough (Coville, BULLETIN, xii. 53); Tioga Co., near Appalachin (C. D. Fretz, BULLETIN, ix. 72).

Vermont—near Ripton (Brainerd, BULLETIN, viii. 6).

New Jersey—Warren Co., swamp near Washington (Garber, Porter).

Maryland—near Oakdale (J. Donnell Smith).

This fine species has always been referred to the European *P. cæruleum*, L., from which it differs in its horizontal stout rootstocks, more leafy stem, exserted stamens, rounded (not mucronulate) petals, accrescent calyx which becomes twice or three times the size of that of *P. cæruleum*, broader and fewer leaflets, and fewer ovules. I take pleasure in dedicating it to the lady who has supplied such fine and numerous specimens by means of which the

marked differences between it and the European plant may be pointed out.

The Rocky Mountain plant referred to *P. cæruleum*, but well separated by Professor Greene (Pittonia, ii. 75), as *P. occidentale*, has slender rootstocks, the upper part of the stem viscid pubescent, narrower, lanceolate leaflets and stamens only the length of the corolla, the fruiting calyx not nearly as large, and its lobes obtuse or obtusish. As pointed out by him, the subterranean parts of the true *P. cæruleum* are widely different from either of the American species. He supposes that the Appalachian plant is the same as the Colorado species, but Mrs. Van Brunt's specimens, taken with the others that I have seen, render that view untenable.

The foliage of *P. Van-Bruntiæ* bears considerable resemblance to that of *P. reptans*, L., but that plant is well marked by its diffuse habit, flowers half the size, stamens included, and calyx lobed only about one-third of its length, the lobes obtuse.

PHLOX KELSEYI, n. sp.

Many-stemmed from a woody root, the stems spreading, creeping or ascending, sometimes 20 cm. long, glabrous or slightly pubescent above, very leafy. Leaves sessile, oblong or linear-oblong, glabrous or nearly so on both sides, 5-15 mm. long, 2-4 mm. wide, thick, rigid, the apex mucronately tipped with a short spine, the margins revolute, ciliate; upper leaves narrower and longer than the lower; flowers sessile or short-peduncled, the peduncles and calyx somewhat glandular-pubescent or glabrous; calyx-teeth subulate, as long as or longer than the tube; corolla tube somewhat exceeding the calyx-lobes; corolla-limb, about 1.5 cm. broad, bright blue or lilac, its lobes obovate-cuneate, rounded.

Helena, Mont. (F. D. Kelsey); Madison Co., Mont. (F. Tweedy, No. 154); Ft. Buford, N. Dakota (V. Havard); Black Hills (Jenney).

This plant, which I confidently propose as an undescribed species, is apparently nearest to *P. longifolia*, Nutt., var. *Stansburyi* (Torr.), forma *brevifolia*, A. Gray, Proc. Amer. Acad. viii. 225, changed to sub-var. *brevifolia*, A. Gray, in the botany of the 40th parallel and to var. *brevifolia*, A. Gray in the Synoptical Flora of North America. From the remarks at the place of

original publication Dr. Gray evidently intended *breviflora* to apply to the shorter-leaved forms of the viscidly glandular southwestern *P. longifolia*, var. *Stansburyi*, such as illustrated by No. 896 of the 40th parallel collection, and hence *brevifolia* is not to be regarded as a synonym of the species here proposed, although Dr. Gray subsequently so-named Mr. Jenney's Black Hills specimens here referred to *P. Kelseyi*.

The status of *Stansburyi* as a variety of *P. longifolia* does not appear to me to be satisfactory. *P. longifolia* is a very narrow-leaved plant, almost glabrous throughout, and is of northwestern range. *Stansburyi* is viscidly glandular, with broader leaves and of southwestern distribution. Types of both are in our herbarium.

I am indebted to Dr. B. L. Robinson for a comparison of my specimens with those in the Gray herbarium.

CYPERUS DIANDRUS, Torr., var. ELONGATUS n. var.

Spikelets linear, acute, slender, 2-2.5 cm. long; scales, or some of them, brown-margined as in var. *castaneus*.

This plant was collected in 1865 at Summit, N. J., by Mr. Wm. H. Leggett, and again last year by Mr. E. P. Bicknell at Van Cortlandt, N. Y. Its much elongated spikelets give it a very different appearance from the var. *castaneus*, with which it grew at both localities.

Eriocaulon bilobatum, n. sp.

BY THOMAS MORONG.

Stems numerous, 2-2½ inches high, very slender, about 5-striate. Leaves acuminate, pellucid, 3-5-nerved, spreading, ½-¾ inch long. Sheaths usually bilobed at the apex, loose, somewhat longer than the leaves. Heads ovoid, 1-1½ lines high, very glabrous and dark-colored. Involucral scales ovate, obtuse, entire, fuliginous. Bracts as long as the flowers, elliptical, glabrous. Segments of the perianth 6: of the fertile flower, thread-like, glabrous or slightly woolly, greenish or fuscous in color, loosely cellular in structure, about ½ line high, the tube white; sterile flowers in the apex of the head about the size of the fertile, but the perianth segments broader, lanceolate in shape, glabrous and fuscous, often reduced to 2 in both the outer and inner perianth. Stamens 6, anthers mostly white. Receptacle smooth. Seeds oval, about $\frac{1}{75}$ of an inch in length, the surface covered with crested ridges or imperfect recticulations.

Pringle, No. 3,855, distributed under the name *E. Jaliscanum*, S. Wats., from which species it differs in several marked particulars. *E. Jaliscanum* has mostly depressed-globose heads, the scales and bracts broader, pale or white, the perianth segments white, linear-lanceolate, and both bracts and segments white-bearded; seeds sculptured with ten or twelve rows of oblong, rectangular or hexagonal reticulations, the raised lines of which appear knobbed or toothed.

Collected by Mr. Pringle Oct., 1891, in wet places near Guadalajara, Mexico, the same locality at which *E. Jaliscanum* was obtained the previous year, and brought to my notice by Pres. Ezra Brainerd of Middlebury College.

Programme of the International Botanical Congress of Genoa, 1892.

Sunday, Sept. 4, 8 p. m.—Reception of Foreign Botanists (Municipal Hall).

Monday, Sept. 5, 9:30 a. m.—Inauguration of the Congress (Great Hall of the University). 2 p. m.—First Scientific Sitting (Great Hall).

Tuesday, Sept. 6, 10 a. m.—Inauguration of the Hanbury Institute (Botanical Garden). 2 p. m.—Second Scientific Sitting (Great Hall).

Wednesday, Sept. 7, 9 a. m.—Third Scientific Sitting (Great Hall). 2 p. m.—Visit to the Exhibition and to the town.

Thursday, Sept. 8, 8. a. m.—Trip by sea to Portofino—thence by carriage to S. Margherita, Rapallo, Ruta and Recco, returning by steamer.

Friday, Sept. 9, 9 a. m.—Fourth Scientific Sitting (Great Hall). 2 p. m. Fifth (and last) Scientific Sitting (Great Hall).

Saturday, Sept. 10, 7 a. m.—Excursion to Ventimiglia and to Mortola. Visit to Mr. Th. Hanbury's Garden.

Sunday, Sept. 11,—Excursion from Ventimiglia to the Col di Tenda.

DIRECTIONS AND SUGGESTIONS.

The International Botanical Congress will be held at Genoa between the 4th and 11th September, 1892. The duration of the

Congress may be prolonged, should it be deemed advisable, in consequence of the abundance of subjects for discussion or for other reasons approved by the Assembly.

Anybody occupied in botanical study or cultivating any special branch of botany will be entitled to take part in the Congress.

To be inscribed as a member of the Congress, it will be necessary to sign and forward to the Secretary of the organizing Committee (Prof. O. Penzig, R. Università, Genoa) the printed form distributed for this purpose by the Committee, or to inscribe oneself during the period of the Congress in a book provided for the purpose.

Every member of Congress will pay a fee of ten francs on receiving his admission card. The members of the Italian Botanical Society will be exempt from this fee.

The admission cards (or season tickets) give access to all the sittings of the Congress, the right to take part in the excursions and entertainments proposed, etc., and also admittance to the Museums, Libraries and Collections which at that period will be open to the members of the Congress. As the presentation of these cards will frequently be necessary, members are therefore recommended to carry them constantly with them during the whole time of the Congress.

All the sittings of the Congress will be held in public, but the right to speak and take active part in the discussions and voting will be reserved for members only.

The official language of the Congress will be in Italian, but it will be free to everybody when speaking or in discussions to use whatever language he may be most familiar with.

No particular subdivisions of the various branches of Botany will be instituted, with separate meetings for each, unless the number of members present and the abundance of subjects to be discussed should render such divisions necessary.

It was not considered advisable to fix any special subjects for discussion, but it is as well to mention from the first that the Reform of Botanical Nomenclature will be treated in accordance with O. Kuntze's recent book, and that lectures are already announced on the theories of F. Delpino respecting Phyllotaxis and Pseudanthia.

The subjects to be proposed for discussion during the scientific sittings must be notified to the Secretary of the Committee not later than the 15th of August, 1892. The subjects notified after that date will only be admitted, if, after exhausting all the other subjects regularly notified, sufficient time should still remain for their discussion.

After the introduction of each subject for scientific argument, the discussion of the same will be in accordance with the usual parliamentary rules.

After the Congress, the Committee will print a brief account of the meetings, and will publish also the originial memoirs presented to the Congress. Every member of the Congress will be entitled gratis to a copy of these "Proceedings of the Botanical Congress of 1892."

To insure the prompt publication of the Proceedings it is indispensible that the authors of each memoir should hand in their manuscripts, ready for printing, before the closing of the Congress, or at least within the month of September, 1892. The memoirs will appear in the volume in the same order as the manuscripts are delivered. After September no more manuscripts can be accepted. The only memoirs which will be included in the Proceedings of the Congress will be those drawn up by members of the Congress, and of which at least a summary shall have been laid before one of the scientific meetings.

The authors of the memoirs printed in the Preceedings of the Congress will each receive gratis fifty separate copies of their writings. Should they require a greater number of copies, they will have to pay (direct to the printer) the cost of paper and printing of the same, according to the special tariff establised by the Committee with the printer. The memoirs may be written in any language which does not require printing in other than Roman type. Any illustrative plates accompanying the manuscripts will be published in proportion to the funds at the disposal of the Congress. Authors must attend themselves to the correction of the proofs of their own work and must assume the responsibility for the same.

The seat of the Congress will be in the palace of the Royal University of Genoa (Via Balbi) where all the meetings will be

held and where will be found the receiving office (for the delivery of admission tickets, incriptions, etc.), the meeting-room of the Committee, the writing-rooms, buffet, post office, telephone, etc., reserved for members of the Congress.

Arrangements have been made with the Italian and foreign railway companies and also with the chief steam navigation companies to obtain the usual reduction of fares for the members of the Congress. It is urgently requested that the printed forms of assent may be returned to the Committee not later than July 1, 1892, so that the drawing up and forwarding of the relative papers may be carried out in good time.

An office where information concerning lodgings will be obtainable will be opened at the Municipality of Genoa.

Signed for the Committee, PROF. O. PENZIG, *Secretary.*

Botanical Notes.

Note on some Characeæ. The Characeæ sent from the Department of Agriculture, collected in the Sand Coulee of Montana by Mr. Williams, were determined by me some time ago, as stated in BULLETIN, vol. xviii. p. 194. Later Characeæ from Crater Lake, on Mount Agassiz, caused me to review more critically the above collection of Mr. Williams, and I find that the plants named *Nitella opaca* occur also in Crater Lake, and differ from *N. opaca* so decidedly as to form a new species which I have named *N Montanæ.* A description and illustration are in preparation, with a revision of the "opaca" section of *Nitella*, giving us two new allied species, namely, *N. Temiscouatæ* and *N. Montanæ.*

Chara evoluta, Allen, from British America, is probably identical with *C. Altaica*, A. Br. T. F. ALLEN.

The editor of "La Notarisia" requests all those who are interested in the study of Algæ, to send him a copy, (or, if possible, two,) of such writings as they may publish from time to time, it being his intention to have them reviewed in his publication. They will receive in return a copy of "La Notarisia" containing the review, or a reprint of the same. "La Notarisia" publishes all "oblata and desiderata" and any other communications that may be of interest to algologists.

All communications should be addressed to Dr. David Levi-Morenos, Piscina San Samuele, 3422, Venezia, Italy.

Index to Recent Literature Relating to American Botany.

Additions to the Catalogue of San Francisco Plants. Katharine Brandegee (Zoë, iii. 49, 50).

Notes on twenty species additional to the list published last year.

American Species of the Genus Anemone and the Genera which have been referred to it. N. L. Britton. (Annals N. Y. Acad. Sci. vi. 215-238; Contrib. Herb. Col. Coll. No. 23).

The six genera *Pulsatilla*, *Anemone*, *Hepatica*, *Capethia*, *Barneoudia* and *Syndesmon* (*Anemonella*), included by recent authors in *Anemone* are maintained as distinct. *A. patens*, var. *Nuttalliana*, A. Gray, is taken up under the name *Pulsatilla hirsutissima* (Pursh); *Anemone decapetala*, Ard. (1764) is *A. heterophylla*, Nutt. (1838); *A. sphenophylla*, Pœpp., is the southwestern Rocky Mountain plant hitherto referred to *A. decapetala*, L.; *A. Tetonensis*, Porter, is a new species from Idaho; *A. Lyallii*, from the Northwest, *A. Peruviana*, from Peru, and *A. Hemsleyi*, from Mexico, are also described as new; *A. nudicaulis*, A. Gray, from Lake Superior, proves to be *Ranunculus Lapponicus*, L. *Capethia* (anagram of *Hepatica*) is the generic name proposed for two plants of the higher Andes. *Barneoudia Balliana* is a new species from the Argentine Republic.

Archegonium and Apical Growth of the Stem in Tsuga Canadensis and Pinus sylvestris—On the. D. M. Mottier (Bot. Gaz. xvii. 141-143; one plate).

Asclepias stenophylla and Acerates auriculata—The Identity of. J. M. Holzinger. (Bot. Gaz. xvii. 160).

A supplementary note in which Mr. Holzinger corrects his mistake of taking up the name *Asclepias auriculata* for this species, there being a previously published *A. auriculata*, Kunth. But is it not more an *Acerates* than an *Asclepias*? N. L. B.

Ascyrum Crux-Andreæ. C. S. Sargent. (Gard. & For. v. 256, f. 49).

Beiträge zur Kenntniss der Gattung Tropeolum. F. Buchenau. (Engler's Bot. Jahresb. xv. 180-259).

Herr Buchenau recognizes forty-four species of this genus distributed from Central America to Chili, several of them here first described.

Communicability of Peach Yellows and Peach Rosette—Additional Evidence on the. Erwin F. Smith. (U. S. Depart. Agric. Bull. No. 1. 1891, illustrated).

Cross-Breeding and Hybridizing, with a Brief Bibliography of the Subject. L. H. Bailey. (The Rural Library, Vol. i. No. 6, pp. 44).

Cuphea viscosissima—Ueber die Epidermis der Samen von. C. Correns. (Ber. Deutsch. Bot. Gesell. x. 143-152, one plate).

Current Methods in Botanical Instruction. Conway Macmillan. (Pamph. pp. 8).

Flora Brasiliensis. Fasciculus CXI., Malvaceæ, Part II.

This completes Vol. xii., Part III. The genera *Malachra, Urera, Pavonia, Gœthea, Malvaviscus, Hibiscus, Kosteletzkya, Cienfugosia* and *Gossypium* are treated by Herr M. Gürke, and the geographical distribution and economic aspects of the Malvaceæ, by Dr. C. Schumann. The fascicle is illustrated by thirty-two plates.

Flora of Central Arizona. J. W. Toumey. (Bot. Gaz. xvii. 162-164.

Forms of Trees as Determined by Climatic Influences. Gustav Eisen. (Zoë, iii. 1-12).

Fungous Diseases of the Celery—Some. (New Jersey Ex. Sta. Bull. April, 1892).

Illustrations are given by Dr. Halsted of *Cercospora Apii, Phyllosticta Apii, Septoria Petroselini*, var. *Apii*, and *Puccinia bullata.*

Germination of the Teleutospores of Ravenelia cassiæcola. B. M. Duggar. (Bot. Gaz. xvii. 144-148; two plates).

Laboulbeniaceæ—Further Additions to the North American Species of. Roland Thaxter. (Proc. Amer. Acad. Arts & Sciences xxvii. 29-45; reprint).

Dr. Thaxter has detected thirty species of this order additional to those recorded in his former paper, making in all forty-nine North American species. *Ceratomyces*, *Corethromyces* and *Acanthomyces* are new genera, and many new species are described in *Heimatomyces* and *Laboulbenia*.

Lilium Grayi. J. G. Baker. (Curt. Bot. Mag. tab. 7,234).

A description of and note on the lily first gathered by Dr. Gray on Roan Mountain in 1840.

List of Species of the Genera Scirpus and Rynchospora occurring in North America. N. L. Britton. (Trans. N. Y. Acad. Sci. xi. 74-93: Contrib. Herb. Col. Coll. No. 26).

Thirty-six species of *Scirpus* are enumerated. *S. Peckii* from northern New York is described as distinct from its relatives, *S. polyphyllus* and *S. sylvaticus*; *S. microcarpus*, Presl., is maintained as a species; *S. Mexicanus*, Clarke, is *S. cyperoides*, Hemsley (1885), not Sprengel (1825); *S. Potosina*, Clarke, is a new species from Mexico (Pringle 3,175); *S. Hallii* and *S. Smithii* are maintained as species; *S. Americanus*, Pers. (1805) antedates *S. pungens*, Vahl. (1806), and a var. *longispicatus* of it from Colorado and New Mexico is described as new; *S. cylindricus* (Torr.) antedates *S. macranthus*, Bœckl. (1858), *S. leptolepis*, Chapm. (1860) and *S. Canbyi*, A. Gray (1864); *S. Californicus* (C. A. Meyer), antedates *S. Tatora*, Kunth.

Sixty species of *Rynchospora* are recognized. *R. Tracyi* is *Ceratoschœnus capitatus*, Chapm., not *R. capitata*, R. & S.; and several new varieties are described.

Loco Weeds. Alice Eastwood. (Zoë, iii. 53-58).

Manual of the Phanerogams and Pteridophytes of Western Texas Gamopetalæ. John M. Coulter. (Contrib. U. S. Nat. Herb. ii., Part 2).

This is the second part of Professor Coulter's useful flora of western Texas. *Perityle Vaseyi* is figured. The following corrections are made in his previously published account of Mr. Nealley's collections: *Aplopappus Texanus*, Coulter, proves to be *Haxloesthes Greggii*, A. Gray, and *Viguiera longipes*, Coulter, is *Zexmenia hispida*, A. Gray, which is also figured; *Ipomœa Nealleyi* Coulter is *Antirrhinum maurandioides*, A. Gray, and *I. Tex-*

ana Coulter is the South American *I. fistulosa*, Mart., escaped from cultivation. A considerable number of plants hitherto unknown north of the Mexican border are here recorded as Texan.

Mariposa County as a Botanical District. J. W. Congdon (Zoë, iii. 25-43).

A very interesting account of the general flora features of Mariposa County, California, with especial reference to geographic distribution.

Notes on Liliaceæ—II. Carl Purdy (Zoë, iii. 43, 44).

Marsilia vestita—On the Prothallium and Embryo of. Douglas Houghton Campbell. (Extract Proc. Cal. Acad. Sci. Ser. ii. Vol. iii).

Metaspermæ—The Embyro-sac of the. Conway Macmillan. (Bot. Gaz xvii. 161, 162).

New or Noteworthy Species. Edward L. Greene. (Pittonia, ii. 222).

Lotus Biolettii, *Trifolium fucatum*, Lindl., *T. flavulum*, *T. virescens*, *T. Gambelii*, Nutt., *Alyssum Americanum*, *Streptanthus Biolettii*, *S. pulchellus*, *Ranunculus Biolettii*, *Bolelia humilis*, *Erigeron leptophyllus*, *E. hyperboreus*, *E. Turneri*, *Callichroa nutans* (*Callichroa* antedates *Layia*); *Psacalium strictum* = *Prenanthes stricta*, Greene (1889) = *Luina Piperi*, Robinson (1891); *Silene purpurata*, *Cerastium grande*, *Tissa rubra*, var. *perennans*; *Brevoortia venusta*, *Fritillaria recurva*, var. *coccinea*; *Plagiobothrys Californicus*, *Allocarya stricta*, *Cryptanthe Kelseyana*, *Cryptanthe Bartolomæi* and *Collinsia arvensis* are described as new.

Notes on Carex.—XVI. L. H. Bailey. (Bot. Gaz. xvii. 148-153).

Notes on new localities for a number of rarer species and the following described as new: *Carex herbariorum*, *C. Pringlei*, *C. xerantica*, *C. Montanensis*, *C. bella* and *C. varia*, var. *australis*.

Notes on the Flora of Staten Island. Arthur Hollick. (Proc. Nat. Sci. Assn. Staten Island May 14th, 1892).

Record of additions to the lists of plants and of new localities for some rare species.

Novitiæ Peruvianæ. A. Zahlbruckener. (Ann. K. K. Naturhist. Hofmuseums Wien, vii. Heft 1 and 2; reprint, pp. 10).

New species from Peru are described in the genera *Viburnum*, *Psychotria*, *Rudgea*, *Myrsine*, *Conomorpha*, *Styrax*, *Nathusia*, *Echites*, *Solanum*, *Athenæa*, *Columnea*, *Amphilophium* and *Mesophæum*.

Officinelle Iridaceen Brasiliens. Theodor Peckolt. (Phar. Rundschau x. 132).

The medicinal properties of *Cipura paludosa*, *Alophia Sellowiana*, *Cypella coerulea*, *C. Northiana*, *Polia Sonariensis*, *Lansbergia cathartica*, *L. purgans*, *L. Caracasana* and *Sisyrinchium galaxoides* are noted.

Oncidium Gravesianum. R. A. Rolfe. (Gardn. Chronicle xi. 650).

A description with illustration of this new orchid from Brazil.

Opuntia Rafinesquii. (Meehan's Month. ii. 81, 82, colored plate).

Palæontology of the Cretaceous Formation on Staten Island. Arthur Hollick. (Trans. N. Y. Acad. Sci. xi. 96-104, 3 plates Contrib. Geol. Depart. Col. Coll. No. 2).

A preliminary note on the Cretaceous plants and mollusks hitherto found on Staten Island, with a description of the strata and mode of occurrence. The following plants are figured: *Protæoides daphnogenoides*, *Laurus plutonia*, *Sapindus Morisoni*, *Thinfeldia Lesquereuxiana*, *Eucalyptus Geinitzii*. *Liriodendron simplex*, *L. primævum*, *Rhamnus Pfaffiana*, *Ficus atavina*, *Dalbergia hyperborea*, *Diospyros primæva*, *Platanus Newberryana*.

Parastic Fungi. Adolph Lehman. (Ottawa Nat. vi. 38).

Pennsylvania Hardwood Forests. J. T. Rothrock. (Hardwood i. No. 8).

Pilocarpus pennatifolius. J. S. Hooker. (Curt. Bot. Mag. tab. 7235).

Plantæ Glazioviana novæ vel minus cognitæ. P. Taubert. (Engler's Bot. Jahrb. xv. Beiblatt No. 34).

New species from Brazil are described in the genera *Dactylæna*, *Paypayrola*, *Galipea*, *Cusparia*, *Metrodorea*, *Hortia*, *Dulacia*, *Licania*, *Hirtella*, *Combretum*, *Fuchsia*, *Abatia*, *Auxemma* and

Diosevrea. Herr. P. Hennings describes new species of fungi in the genera *Uromyces, Puccinia, Hymenochæte, Cladoderis, Polyporus, Phyllachora* and *Helotium.*

Practical Studies in Biology. I. The Potato. H. L. Osborn. (Amer. Month. Micros. Journ. xiii. 85-88; 105-110; illustrated).

Revision of the American Species of Rumex Occurring North of Mexico. Wm. Trelease. (3rd Ann. Rep. Missouri Bot. Gard. 74-98; plates 13-33; reprint).

Prof. Trelease recognizes twenty species of the genus within the area. *R. paucifolius,* Nutt. becomes *R. Geyeri* (Meisn.) the older name; *R. Arizonicus,* Britton, is referred to *R. hymenosepalus,* Torr. in which reduction we have no doubt he is in error, and all the North American plant which has gone as *R. maritimus,* is referred to *R. persicariodes,* L. The paper is illustrated by twenty plates, and will greatly facilitate the determination of these plants. N. L. B.

Restrepia striata. J. T. Hooker. (Curt. Bot. Mag. xlviii. tab. 7233).

Sereno Watson. John M. Coulter. (Bot. Gaz. xvii. 137-141, with portrait and interior view of the herbarium of Harvard University).

Spiræaceæ—On Certain. Edward L. Greene. (Pittonia, ii. 219-222).

Lutkea Hendersonii, from the Olympic Mts., Washington, is characterized as new. Professor Greene maintains *Spiræa corymbosa,* Raf., *S. lucida,* Dougl. and *S. pyramidata,* n. sp., all as distinct from the Siberian *S. betulæfolia,* Pall., to which he refers as American only a specimen from Alaska.

Systematische Stellung der Gattung Thorea, Bory. Fr. Schmitz. (Ber. Deutsch. Bot. Gesell. x. 115-143).

Tertiary Fossil Plants from Potosi, Bolivia. N. L. Britton. (Trans. Amer. Inst. Mining Engineer, Plattsburgh, Meeting, June, 1892; Contrib. Herb. Col. Coll. No. 27, Reprint, pp. 10; 79 figures).

This collection of fossil plants was made by Drs. A. F. Wendt and F. A. Canfield, engineers of the famous silver mines of Potosi. The following species are described as new: *Porliera tertiaria*, *Amicia antiqua*, *Cassia Wendtii*, *Escallonia Wendtii*, *Terminalia Wendtii*, *Cuphea antiqua*, *Passiflora* (?) *Canfieldi*, *Myrica Potosina*, *M. Engelhardtii* and *M. Wendtii*.

Tovariaceen—Zur Kenntniss der. G. de Lagerheim. (Ber. Deutsch. Bot. Gesell. x. 163-170).

A discussion of the systematic position of the genus *Tovaria*, R. and P.

Your Weeds and Your Neighbor's. C. F. Millspaugh. (Bull. W. Va. Agric. Exper. Sta.)

Dr. Millspaugh, as botanist of the West Virginia Experiment Station, is making a thorough study of the weeds of his State, the results of which are appearing in a series of bulletins under the above title. Part II deals with the distribution of weeds, their bad points, uses for fodder, and chemical weed exterminators.

Proceedings of the Club.

Tuesday Evening, May 10th, 1892.

The President in the chair and forty-seven persons present.

Mrs. Britton gave the announced paper of the evening on "Mosses, their Structure and Classification," illustrated by living and herbarium specimens and lantern slides.

Wednesday Evening, May 25, 1892.

Vice-President Mr. Thos. Hogg in the chair and twenty persons present.

The Secretary announced the death since the last meeting of Miss Phoebe McCabe, long an active member of the Club. Miss Steele and Mrs. Britton were appointed a committee to draw suitable resolutions expressive of the sentiments of the Club.

The Editor announced the death of Dr. Edouard von Regel,

Director of the Botanical Garden at St. Petersburg, an honorary member. Dr. Britton, Dr. Porter and Dr. Morong were appointed a committee to draw resolutions expressing the sense of loss which the Club feels in the decease of this distinguished botanist.

The committee has prepared the following memorial:

In memory of Dr. Edouard von Regel, in whose recent death the club loses one of its most distinguished Honorary Members, we adopt the following minute:

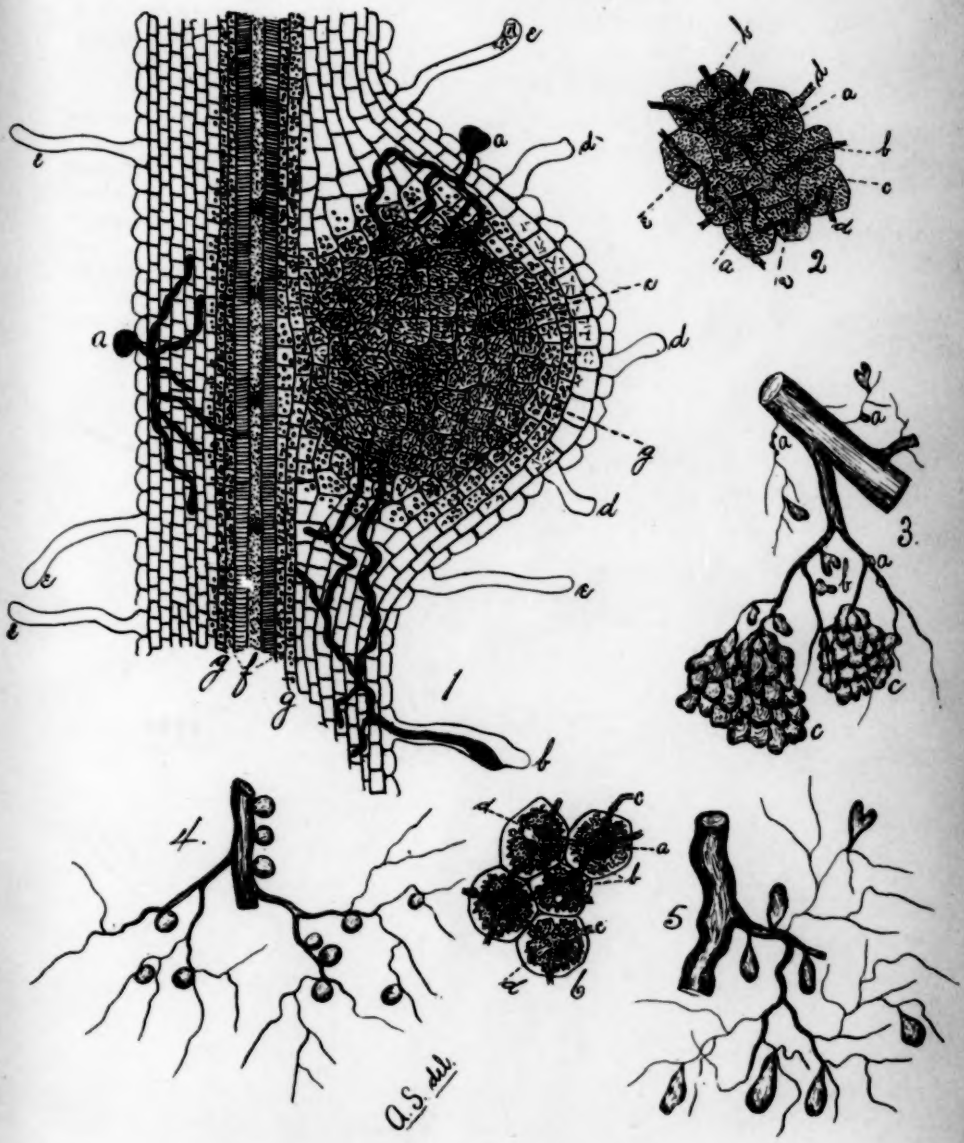
Dr. Regel is well-known as the author of numerous botanical works of great value, the first of which was published in 1843. Since that date he has contributed about a dozen works to the science, one of the most important being his monograph on Betulaceæ, published in Vol. 16 of the Prodromus of DeCandolle. For many years he has been the Director of the Botanical Garden at St. Petersburg, in which position he has contributed largely to the collection, determination and distribution of the plants of the Russian Empire. He is best known, perhaps, in connection with the northern Asiatic flora, in the arrangement and enumeration of which the latter years of his honored and useful life have been spent.

His death, occurring so soon after that of his great colleague, Maximowicz, is a heavy affliction to our associates at St. Petersburg, leaving a void not easily filled. We desire to express our profound sympathy with them under their bereavement, as well as to testify our high appreciation of the services which Dr. Regel has rendered to the world at large.

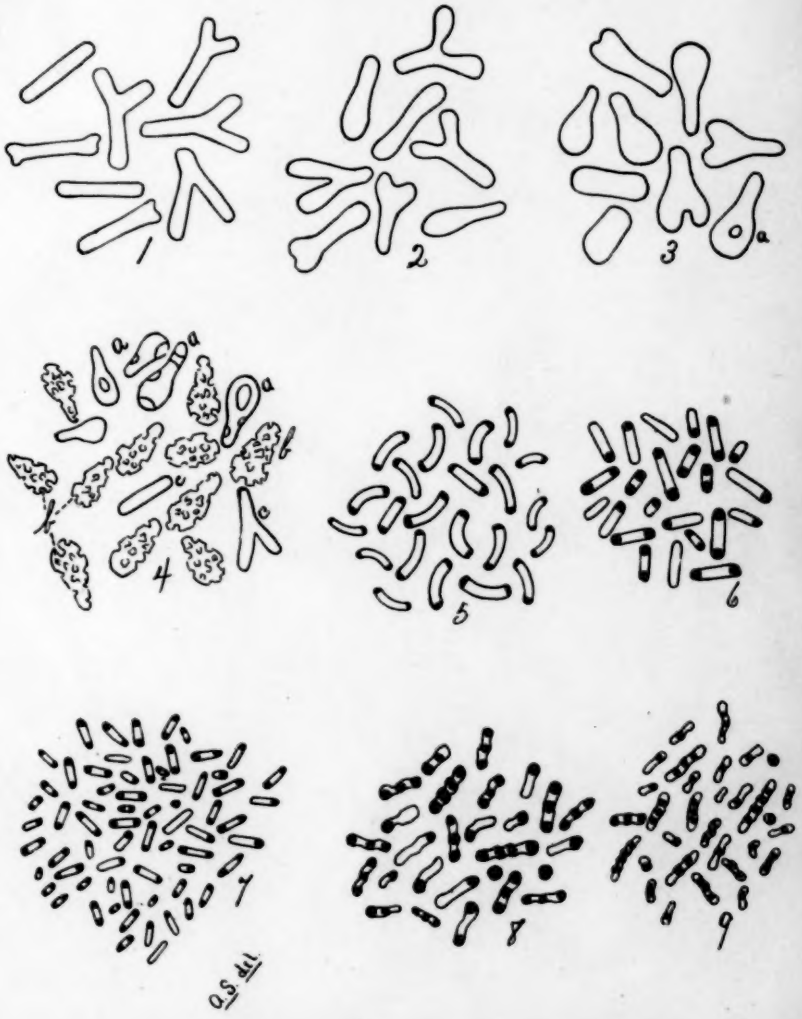
N. L. Britton,
Thomas Morong,
Thos. C. Porter.

Dr. Emily L. Gregory gave the announced paper of the evening on "Some Facts in Reference to Old and New Views on Plant Physiology."

The Club then adjourned until the second Tuesday evening in October.



SOME AMERICAN RHIZOBIA. A. Schneider.



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